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4G, 5G, 6G, 7G and Future Mobile Technologies

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Abstract

From past year wireless technology makes tremendous growth. Evolution and revolution of wireless technology is reached at 7.5G. Wireless technology FG (Future Generation) mobile communications will have higher data transmission rates than 6G and 7G. Wireless technology is continuously one of the hottest areas that are developing at a high speed, with advanced techniques emerging in all the fields of mobile and wireless communications. Current times are just the beginning for deploying 5G mobile communication systems. At present we have many technologies each capable of performing functions like supporting voice traffic using voice over IP (VoIP), broadband data access in mobile environment etc., but there is a great need of deploying such technologies that can integrate all these systems into a single unified system. 8G presents a solution of this problem as it is all about seamlessly integrating the terminals, networks and applications. In this paper an attempt has been made to provide a study of different cellular technologies namely 4G, 5G, 6G, 7G, and FG respectively and detail comparison among them.

Keywords: Cellular generations; Mobile technologies; Networks; Communication

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Introduction

The mobile communication systems and the wireless communication technologies have been proving very fast day by day. Wireless communication is the transfer of information over a distance without the use of enhanced electrical conductors or "wires" When the context is clear, the term is often shortened to "wireless" It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, Personal Digital Assistants (PDAs), and wireless networking [1]. In the past few decades, the mobile wireless technologies have experience of various generations of technology revolution and evolution, namely from 0G to 4G. Currently and on future, we are exposing to new cellular generations namely 5G, 6G, 7G, 8G and etc.

Consumers are demanding more advanced and useful applications. Each generation has some standards, capacities, techniques and new features which differentiate it from previous generations. Due to these new features, the number of mobile phone subscribers is increasing day by day. Hence, there is need of capacity improvements in wireless communications. The 4G integrates 3G with fixed Internet to support wireless mobile Internet, which is an evolution to overcome the limitations of 3G and also raises the QoS, increases the bandwidth and reduces the cost of resources. The 5G brings forward a real wireless world-Wireless World Wide Web (WWW) while 6G is proposed to integrate 5G with satellite networks for global coverage. 7G deals with space roaming. The paper is organized in five sections followed by conclusion, recommendation, acknowledgement and references. Section II describes about 4G cellular technologies in detail. Section III gives a detailed explanation about 5G cellular networks. Section IV and V talks about 6G and 7G cellular technologies respectively and section VI gives a detailed comparison of 4G, 5G, 6G, and 7G of cellular technologies.

4G Cellular Technology

T4G is an IP-based technology that uses voice communication. LTE (Long Term Evolution), UMB (Ultra Mobile Broadband) and the IEEE 802.16 (WiMAX) are considered to be 4G standards (**Table 1**) [2].

Network	Peak value of download	Peak value of upload
LTE	100 Mbit/s	50 Mbit/s
LTE advanced	1000 Mbps	500 Mbps
WiMAX	128 Mbit/s	56 Mbit/s

Table 1: Components of haplotypic variation and paired FST value for the 38 complete genome sequences of SARS-COV-2 from South America.

Mobile Web access, IP telephony, gaming services, High Definition (HD) mobile TV, video conferencing, and 3D television are the applications of 4G cellular networks.

The first release of LTE (Long Term Evolution) standard has been commercially deployed in 4G does not support circuit-switched networks but it is an IP-based network system. 4G networks are the pillars as it integrates several radio access networks with fixed Internet networks [3].

In 2009, the ITU-R organization specified the IMT-Advanced (International Mobile Telecommunications Advanced) requirements for 4G standards, setting peak speed requirements for 4G service at 100 Mbit/sec for high mobility communication (such as from trains and cars) and 1 Gbit/sec low mobility communication (such as pedestrians and stationary users). One of the key technologies for 4G and beyond is called Open Wireless Architecture (OWA), supporting multiple wireless air interfaces in an open architecture platform [4].

4G is used also Software Defined Radio (SDR) as one of its technologies. SDR is used to configure or define the radio and make a common platform which can be used across a number of areas. And, it will develop a multi-band, multi-standard base stations and terminals. In future, the terminal will adapt the air interface to the available radio access technology, at present this is done by the infrastructure [5].

The high-level network architecture of LTE is comprised of following three main components: the User Equipment (UE), the Evolved UMTS Terrestrial Radio Access Network (E-UTRAN) and the Evolved Packet Core (EPC) respectively. The evolved packet core communicates with packet data networks in the outside world such as the internet, private corporate networks or the IP multimedia subsystem. The interfaces between the different parts of the system are denoted Uu, S1, and SGi (**Figure 1**).

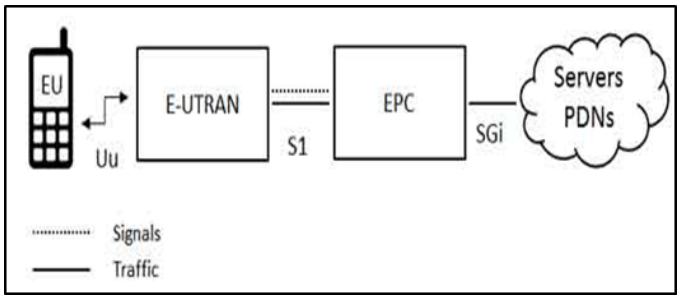

Figure 1: Basic LTE interfaces.

The User Equipment (UE)

The internal architecture of the user equipment for LTE is identical to the one used by UMTS and GSM which is actually a Mobile Equipment (ME). The mobile equipment comprised of the following important modules:

• Mobile Termination (MT): This handles all the communication functions.

• Terminal Equipment (TE): These terminals the data streams.

• Universal Integrated Circuit Card (UICC): This is also known as the SIM card for LTE equipment. It runs an application known as the Universal Subscriber Identity Module (USIM). A USIM stores user-specific data very similar to 3G SIM card. This keeps information about the user's phone number, home network identity and security keys etc.

The E-UTRAN (The access network)

The architecture of evolved UMTS Terrestrial Radio Access Network (E-UTRAN) has been illustrated in **Figure 2**.

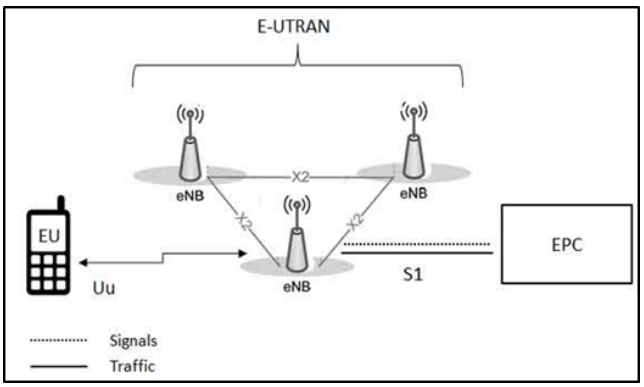

Figure 2: E-UTRAN architecture.

The E-UTRAN handles the radio communications between the mobile and the evolved packet core and just has one component, the evolved base stations, called eNodeB or eNB. Each eNB is a base station that controls the mobiles in one or more cells. The base station that is communicating with a mobile is known as its serving eNB.

LTE Mobile communicates with just one base station and one cell at a time and there are following two main functions supported by eNB:

• The eBN sends and receives radio transmissions to all the mobiles using the analogue and digital signal processing functions of the LTE air interface.

• The eNB controls the low-level operation of all its mobiles, by sending them signaling messages such as handover commands.

Each eBN connects with the EPC by means of the S1 interface and it can also be connected to nearby base stations by the X2 interface, which is mainly used for signaling and packet forwarding during handover. A home eNB (HeNB) is a base station that has been purchased by a user to provide femtocell coverage within the home. A home eNB belongs to a closed subscriber group (CSG) and can only be accessed by mobiles with a USIM that also belongs to the closed subscriber group.

The Evolved Packet Core (EPC-The core network)

The architecture of Evolved Packet Core (EPC) has been illustrated below. There are few more components which have not been shown in the diagram to keep it simple. These components are like the Earthquake and Tsunami Warning System (ETWS), the Equipment Identity Register (EIR) and Policy Control and Charging Rules Function (PCRF) (**Figure 3**).

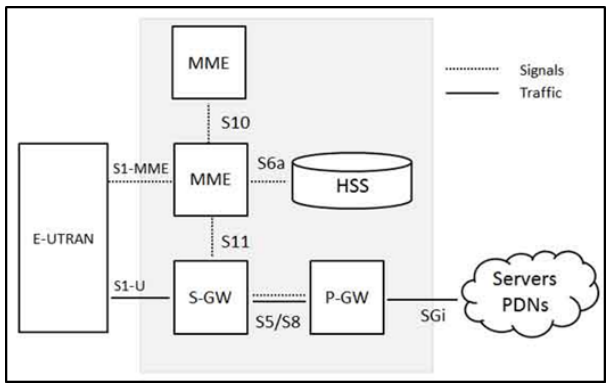

Figure 3: Evolved packet core architecture.

There is a brief description of each of the components shown in the above architecture:

• The Home Subscriber Server (HSS) component has been carried forward from UMTS and GSM and is a central database that contains information about all the network operator's subscribers.

• The Packet Data Network (PDN) Gateway (P-GW) communicates with the outside world ie. Packet data networks PDN, using SGi interface. Each packet data network is identified by an access point name (APN). The PDN gateway has the same role as the GPRS support node (GGSN) and the serving GPRS support node (SGSN) with UMTS and GSM.

• The serving gateway (S-GW) acts as a router, and forwards data between the base station and the PDN gateway.

• The Policy Control and Charging Rules Function (PCRF) is a component which is not shown in the above diagram but it is responsible for policy control decision-making, as well as for controlling the flow-based charging functionalities in the Policy Control Enforcement Function (PCEF), which resides in the P-GW.

The interface between the serving and PDN gateways is known as S5/S8. This has two slightly different implementations, namely S5 if the two devices are in the same network, and S8 if they are in different networks.

5G Cellular Technology

5G mobile network is progressive version of the present 4G/IMT-Advanced standards since 2011. 5G (5th generation mobile networks or 5th generation wireless systems) is a name which used to denote the next major phase of mobile telecommunications standards. 5G is not a term officially used for any particular specification or in any official document yet made public by telecommunication companies or standardization bodies such as 3GPP, WiMAX Forum, or ITU-R. Moreover, new standard releases beyond 4G are in progress by standardization bodies, but are at this not considered as new mobile generations but under the 4G umbrella.

The capacity of the 5G is aimed to be much higher than current 4G. Higher capacity would allow higher density of mobile users, ultra reliability and massive communications. Also, research that is going on 5G aims at lower suspension and low battery consumption.

5G is designed for WWWW (World Wide Wireless Web) and IPv6 is a fundamental protocol used to 4G and 5G cellular networks but since IPv6 assigns any IP address to any mobile node based on location management; therefore, this would cause wastage of 5G resources [6]. According to the resources, 5G would get implemented around the year 2020. It has been noted that a new generation has appeared after every 10th year since 1G cellular network was introduced in 1981, 2G in 1992, 3G was in 2001 whereas 4G came into the market in 2012-2013.

5G core concept would possess three technologies:

• Nano technology

• Cloud computing and,

• All flat IP platform

The 5th wireless mobile Internet networks are real wireless world which shall be supported by LAS-CDMA, OFDM, MC-CDMA, UWB, Network-LMDS and IPv6. IPv6 is a basic protocol for running on both 4G and 5G. Moreover, to solve the wasting of 5G resources due to IPv6 working nature (location management) and 5G aim (WWWW based on network access management), the proposed the bandwidth optimization control protocol and the mix-bandwidth data path for future 5G real wireless world. The Bandwidth Optimization Control Protocol (BDCP) is implemented in between MAC layer and TCP/IP layer, which is used to establish the mix-bandwidth [7].

New mobile generations are typically assigned new frequency bands and wider spectral bandwidth per frequency channel (1G up to 30 kHz, 2G up to 200 kHz, 3G up to 5 MHz, and 4G up to 40 MHz), but sceptics argue that there is little room for new frequency bands or larger channel bandwidths. From users' point of view, previous mobile generations have implied substantial increase in peak bit-rate (i.e. physical layer net bit-rates for short-distance communication). However, no source suggests 5G peak download and upload rates of more than the 1 Gbps to be offered by ITU-R's definition of 4G systems. If 5G appears, and reflects these prognoses, the major difference from a user point of view between 4G and 5G techniques must be something else than increased maximum throughput. For example lower battery consumption, lower outage probability (better coverage), high bit rates in larger portions of the coverage area, cheaper or no traffic fees due to low infrastructure deployment costs, or higher aggregate capacity for many simultaneous users (i.e., higher system level spectral efficiency).

The ultimate goal of 5G is to offer 20 Mbps data rates, even when used in such scenarios as a vehicle traveling 200 kilometers per hour. And, it will support the fixed wireless networks [8].

Besides, 5G technology also used new computing concepts as follows:

Pervasive networks

A user can concurrently be connected to several wireless access

technologies and seamlessly move between them.

Group cooperative relay

To make a high data rates available over a wider area of the cell. Currently, data rates fall towards the cell edge where interference levels are higher and signal levels lower.

Cognitive radio technology

The user equipment/handset to look at the radio landscape in which it is located and choose the optimum radio access network, modulation scheme and other parameters to configure itself to gain the best connection and optimum performance.

Wireless mesh networks and dynamic Ad hoc networking

By using a variety of different access schemes, it will be possible to link to others nearby to provide ad-hoc wireless networks for much speedier data flows.

Smart antennas

By using smart antennas, it will be possible to alert the beam direction to enable more direct communications, limit interference and increase overall cell capacity (**Figure 4**).

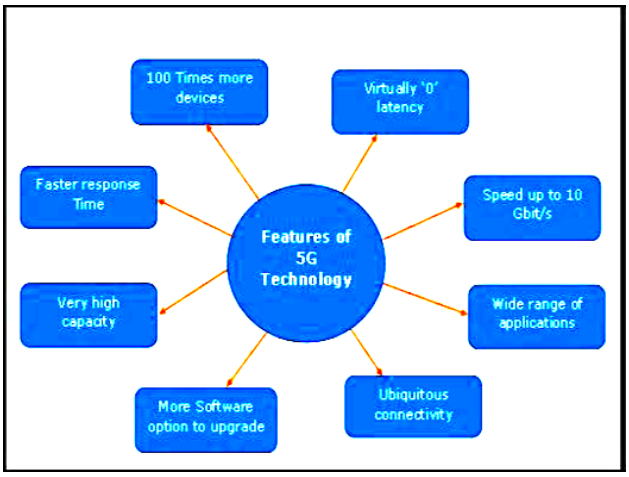

Figure 4: Features of 5G technology.

Architecture of 5G is highly advanced; its network elements and various terminals are characteristically upgraded to afford a new situation. Likewise, service providers can implement the advance technology to adopt the value-added services easily.

However, upgrade-ability is based upon cognitive radio technology that includes various significant features such as ability of devices to identify their geographical location as well as weather, temperature, etc. Cognitive radio technology acts as a transceiver (beam) that perceptively can catch and respond radio signals in its operating environment. Further, it promptly distinguishes the changes in its environment and hence responds accordingly to provide uninterrupted quality service [9].

The system model of 5G is entirely IP based model designed for the wireless and mobile networks (**Figure 5**).

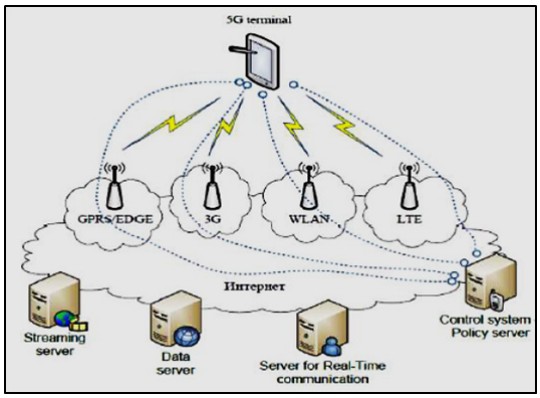

Figure 5: IP based 5G architecture.

The system comprising of a main user terminal and then a number of independent and autonomous radio access technologies. Each of the radio technologies is considered as the IP link for the outside internet world. The IP technology is Moreover, to make accessible routing of packets should be fixed in accordance with the given policies of the user (**Figure 6**).

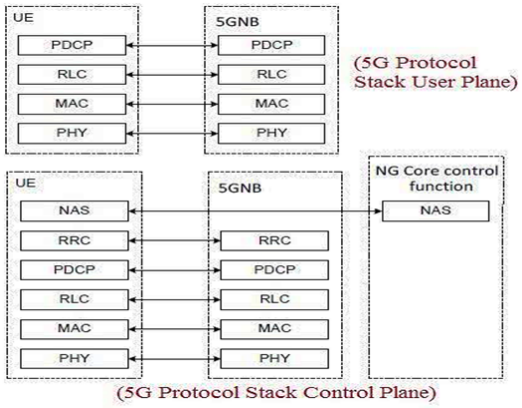

Figure 6: Basic 5G layer.

The 5G Master Core is convergence point for the other technologies, which have their own impact on existing wireless network. Interestingly, its design facilitates Master Core to get operated into parallel multimode including all IP network mode and 5G network mode. In this mode (as shown in the image given below), it controls all network technologies of RAN and Different Access Networks (DAT). Since, the technology is compatible and manages all the new deployments (based on 5G), it is more efficient, less complicated, and more powerful (**Figure 7**).

Surprisingly, any service mode can be opened under 5G New Deployment Mode as World Combination Service Mode (WCSM). WCSM is a wonderful feature of this technology; for example, if a professor writes on the white board in a country – it can be displayed on another white board in any other part of the world besides conversation and video. Further, new services can be easily added through parallel multimode service.

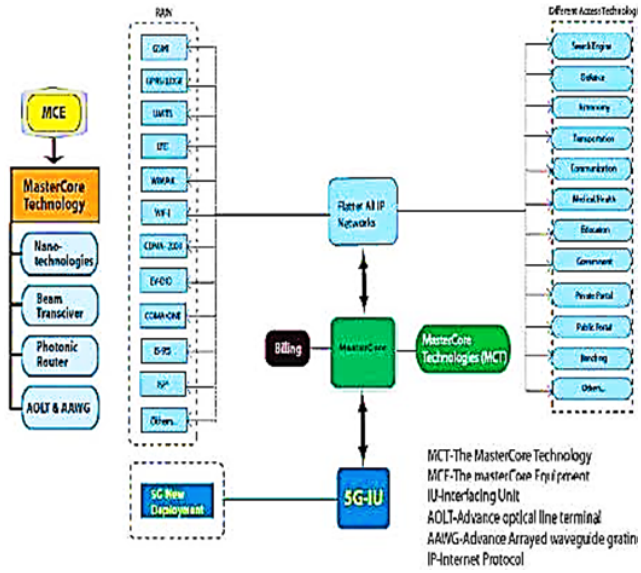

Figure 7: 5G master core.

6G Cellular Technology

6G mobile network/Internet uses an air fiber technology with masts and transceivers on tall buildings and even lamp posts to create a local network capable of delivering phenomenal speeds instead of disappointing averages. The air fiber combination will be the best method to broadcast much secured information from transmitters to destinations. 6G's converged network provides local with a truly all-in-one solution: uploads, downloads, super-fast broadband Internet, multiple line telephones, CCTV monitoring, video conferencing every telecommunications requirement your business needs is catered for with 6G.

The 6th generation (6G) wireless mobile communication networks shall integrate satellites to get global coverage. The global coverage systems have been developed by four countries. The global position system (GPS) is developed by USA, the COMPASS system is developed by China, the Galileo system is developed by EU, and the GLONASS system is developed by Russia. Thus, these independent systems are difficulty for space roaming. The task of 7th generation (7G) wireless mobile communication networks is going to unite [10].

6G Internets use a combination of the latest in radio and fiber optics technology. They deliver through via line of sight (LOS). Which means they don't have to rely on the copper cable or base our speed on how to far your business is away from the exchange. 6G offer faster, more secure and cost-effective broadband network. This mobile system for the global coverage will integrate 5G wireless mobile system and satellite network. These satellite networks consist of telecommunication satellite network, earth imaging satellite network and navigation satellite network. The telecommunication satellite is used for voice, data, Internet, and video broadcasting; the earth imaging satellite network is for weather and environmental information collection; and the navigational satellite network is for Global Position System (GPS).

In 6G hand-off and roaming will be the big issue because those satellite systems are different networks and 6G has four different standards. Thus, the hand-off and roaming must take place between those four different networks but how it will occur is still a question.

In 6G the cost of mobile call will be relatively high but in 7G/7.5G/8G their problem will be reduced and lower level user will benefit from them. In 6G, the globe will be decorated by fly sensors with the help of 6G technology. These fly sensors will provide information to their remote observer stations; further these stations will check any activity upon a special area such as the activity of terrorists, intruders etc., (**Figure 8**).

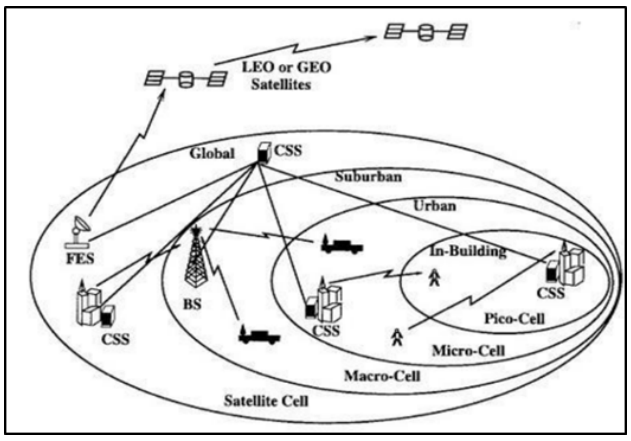

Figure 8: 6G network architecture.

7G Cellular Technology

7G mobile network is like the 6G for global coverage. It will be the most advance generation in mobile communication but there will be some researches on demanding issues like the use of mobile phone during moving condition from one country to another country, because satellite is also moving in constant speed and in specific orbit, the standards and protocols for cellular to satellite system and for satellite to satellite communication system.

The dream of 7G can only be true when all standards and protocols are defined. May be this is possible in next generation after 7G and can be named as 7.5G or 8G. When 7G will complete all its weak points then there will be no issue of data capacity coverage and hand-off left behind. At that time there will be only one demand from user which is the cost of mobile phone call and its services. This issue will again start evolutionary change in standard and technology, and will also open new horizons for computing research. This new revolution in technology for cost of mobile phone call and services will be called as 7.5G or 8G.

Comparison of different cellular technologies

The comparison of different cellular technologies is been illustrated in **Table 2**.

Parameters	Cellular technologies			
	4G	5G	6G	7G
Frequency	2-8 GHz	4G Frequency	95GHz-3THz	95GHz-3THz
Service	Wi-Fi, VoIP, LTE, WiMAX	WWWW	Secured and global cellular services	Secured and global cellular services
Multiplexing	OFDMA	All with AI capabilities, MIMO,CDMA	CDMA	CDMA
Switching type	Packet switching (All packer)	IPv6 but advancements are still to be done	All packet	All packet
Core network	Internet	Internet	Internet	Internet
Data rate	100-300 Mbps	About 100+Mbps	About 11 Gbps	About 11+Gbps
Pros	Speed, high speed hand offs, MIMO tech, global tech	Better coverage area, low battery consumption, availability of multiple data transfer path, energy and spectral efficiency is more and has a high security	Global coverage system	No issue of data capacity coverage and hand off left behind, low cost of call
Cons	Hard to implement, complicated hardware required	It is still under process and research on its viability is going on, it is difficult to achieve because of the incompetent technological support in most parts of the world, developing infrastructure needs high cost, security and privacy issue yet to be solved	Difficulty for space roaming, high cost of mobile call and similar with 5G disadvantages	Similar with 5G and 6G disadvantages
Location of first commercialization	South Korea	Not yet	Not yet	Not yet
Time period	Now	Soon probably 2020	Soon probably 2030	Soon probably 2030
Handoff	Horizontal and vertical	Horizontal and vertical	Horizontal and vertical	Horizontal and vertical

Table 2: Components of haplotypic variation and paired FST value for the 38 complete genome sequences of SARS-COV-2 from South America.

Conclusion

The world of mobile wireless communication is rapidly developing. The last few years have experienced a remarkable growth in wireless industry. Attempts are being made to reduce the number of technologies to a single global standard resulting in 5G, 6G and 7G. 5G aims a real wireless world with no limitations while 6G integrates 5G with satellite networks. Due to variable technologies and standards, with 6G handoff/roaming will be an issue. This drives the 7G of mobile wireless networks which aims to acquire space roaming. Trials have already started on 5G which may lead to its commercial availability around 2020.

The world is trying to become completely wireless, demanding uninterrupted access to information anytime and anywhere with better quality, high speed, increased bandwidth and reduction in cost.

Recommendations

In 5G research that is going on its aims at lower suspension and low battery consumption. Besides, IPv6 assigns any IP address to any mobile node based on location management; therefore, this would cause wastage of 5G resources.

In 6G, hand-off and roaming are big issues due to its satellite systems are working in different networks and standards. Thus, the hand-off and roaming must take place between those four different networks but how it will occur is still a question.

The dream of 7G can only be true when all its standards and protocols are defined. May be this is possible in next generation after 7G. When 7G will complete all its weak points then there will be no issue of data capacity coverage and hand-off left behind. At that time there will be only one demand from user which is the cost of mobile phone call and its services. This issue will again start evolutionary change in standard and technology, and will also open new horizons for computing research. This new revolution in technology for cost of mobile phone call and services will be called as 7.5G or 8G.

In future, the terminal will adapt the air interface to the available radio access technology, at present this is done by the infrastructure. In addition, the main barrier for future technologies success is the incompetent technological support (old devices) in most parts of the world. So, all of them need to

be replaced with new one. Generally, 5G, 6G and 7G requires a high cost for developing infrastructure as well as their security and privacy issues yet to be solved.

Finally, it has been noted that a new generation has appeared after every 10th year since 1G cellular network was introduced in 1981, 2G in 1992, 3G was in 2001 whereas 4G came into the market in 2012–2013. So, 5G is coming in 2020, 6G and 7G will come in 2030 and 2040 respectively.

Acknowledgments

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